

Doing Designs in Times of Shrinking Funds

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INTRODUCTION

It's not the good old days anymore. Gone are the days when we were congratulated for spending more funds than we had and asking for more and getting them. Gone are the days when we were the required design agency. Gone are the days when we could spend and spend without regards to the total design costs. Thank goodness all these days are gone. This paper wouldn't exist if these days were still here. We'd be out of business and working elsewhere. We don't have the luxury any more to say "I can't do that for that amount". We've got to say "I'll do it for that or less" if we want to remain in business. Mindsets must be changed.

The times have changed and still are changing. We are being required to design more for less. We are required (thankfully) to produce quality products on time and within budget. We are being required to produce designs in much less time than in the past. As we do more and more installation support projects, we'll definitely be doing designs very quickly and very inexpensively. Let's take a look at how we got here and how we can still do a quality job in these changing times.

DESIGN COSTS

A GS-12, step five electrical engineer will be used as the "typical engineer" for comparisons in this paper. Other disciplines and costs in other districts are similar except for salaries and markups. As of 1 January 1998, the salary for this engineer in the Mobile District is \$25.93/hour. With markups the salary is \$68.46. Markups will be discussed later.

Since 1980 base salaries for the typical engineer have increased around 86% in current year dollars. This is an average increase of around 4.5%. At the same time, total salary including markups has increased around 149%. Recent increases have been well below the average stated above and the trend is toward 2-3% yearly increases.

Labor markups consist of several items. These are effective costs, overhead costs, and technical indirect costs. The following graphs (figures 1,2,3) depict typical makeups of these costs.

Figure 1

Effective Costs

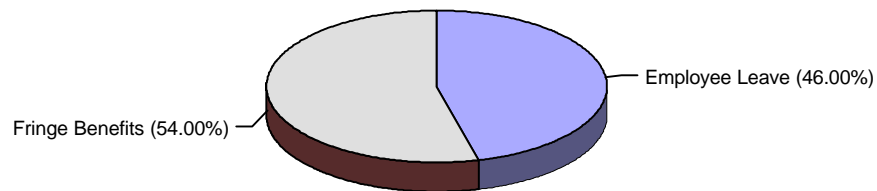


Figure 2

Overhead Costs

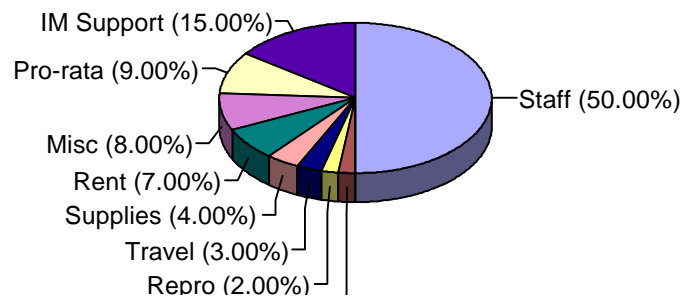
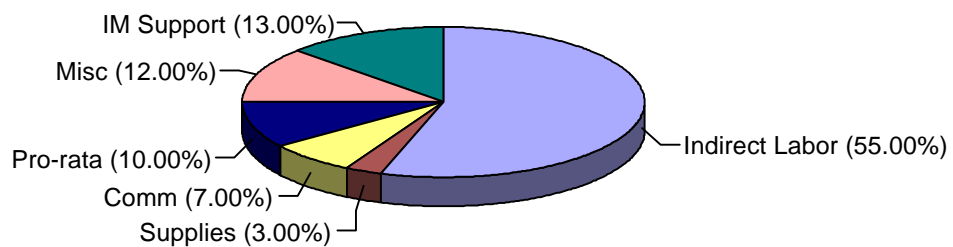


Figure 3

Technical Indirect



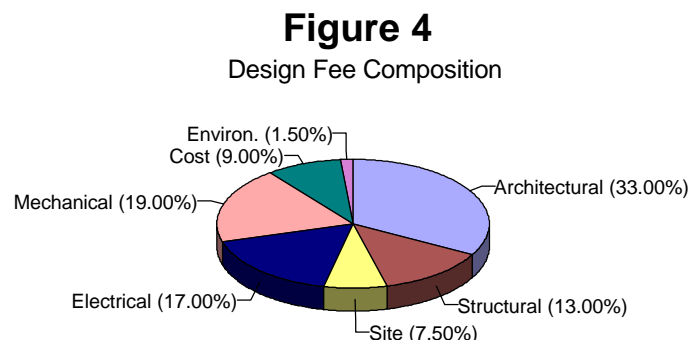
Some of the items in the markups can be directly affected by design methods. These will be discussed later. Current markup

for the Mobile District is 2.64.

Design fees are what we charge and get paid for doing designs for our customers. These fees cover engineering costs, topographic surveys, soils investigations, project management fees, BCOE reviews, travel and a multitude of other costs. Of the total design fee, historical data shows that only 65-70% of the total is strictly for production of plans and specifications. In the past there were no apparent limits on design fees. Most engineers estimated eighty (80) hours per drawing plus additional time for specifications and design analysis. This approach does not work anymore.

Design fees are now governed by prescribed design targets prescribed by headquarters. These targets are based on the programmed amount (PA) and get smaller as the PA gets larger. Attached in Attachment "A" is a spreadsheet showing these targets. For projects with a PA of \$1,000,000 and lower, the design target is 16%, or \$160,000. 65-70% of this amount gives only \$104,000-\$112,000 to do a complete design and advertise the project. For purposes of an example, let's assume that we have a project with a PA of \$500,000. As we do more and more installation support project design, projects of this magnitude will be the norm instead of the exception. Let's also assume that the amount to actually produce the plans and specifications is 70% of the total design cost. Let's further break this down by discipline.

Data gathered from Mobile District designs and from the division office and headquarters show that the pure design costs (the 65%-70% of the total design costs) can be broken down as follows:



These are for a typical vertical construction project. For the \$500,000 project, the electrical design fee would

typically be \$9520. The typical engineer would have about 140 hours to complete the design. That's a little more than three (3) weeks to do site investigations, perform engineering calculations, prepare plans and specifications and any other associated tasks.

In 1980 the typical engineer's salary would have been, with markups, \$25.93. In 1980 the same project would have had a PA of \$311,000. Using today's design targets (which were not in effect then), the total design fee would have been about \$49760. The amount available for design would have been \$34,382. The electrical fee would have been \$5921 or 228 hours. So you can see that as costs have increased, actual design time, for this project and this engineer was 63% more at that time. This gap would probably be even larger since there were no design targets and the thinking was spend what ever you need. For larger projects, the gap is even more dramatic. Total these differences for a year and the difference is staggering. As workloads

decrease, the problem just gets worse. We get much less than in the past and have less work but tighter constraints. We need to find and implement innovative methods to do our jobs while giving the customer a quality product.

Following are suggestions and examples of proven methods that can and have been used not only to reduce electrical design costs, but also the overall project design costs. These have been tried and proven in the past five years by the author and others in the Mobile District. These suggestions and recommendations can aid in further reductions in design costs.

DESIGN RELATED COST REDUCTION METHODS

ARCHITECTURAL END ENGINEERING INSTRUCTIONS FOR INSTALLATION SUPPORT

This document contains many methods for producing designs in a fast and cost-effective manner. It also contains similar methods to reduce contracting costs. Some of the design methods have been successfully used and will be described and shown in this paper. It is recommended that this document be required reading in all districts.

ARCHITECTURAL END ENGINEERING INSTRUCTIONS FOR DESIGN BUILD

This is a draft document that prescribes methods and procedures for soliciting and contracting design-build projects. How does this method save design costs? First, the actual design effort in the district is normally carried only to the concept (35%) stage. A project that would normally have a design fee of say 16%, may and probably would have a design fee of 3-5% for this type of effort. The burden for the remainder of design rests with the contractor and the costs for his completion of design are from construction dollars, not design dollars. Errors and omission from the design would be at the expense of the contractor. An additional 1%-3% would be required to review the contractors design. So the total design cost to the customer would be 4%-8%, not 16% for a normal full design. The Air Force is requiring this type of procurement on many of its projects. Some of the Air Force commands are requiring this method on all of their projects. In other words, whether we like it or not, we're going to be doing more and more of our work in this manner.

CD ROM ADVERTISEMENTS

In lieu of massive copies of plans and specifications being reproduced on paper for advertising projects, CD ROM advertisements can and do reduce design costs. Part of the total design cost is the cost for advertising the project. A typical paper advertisement costs around \$7000 while a CD ROM

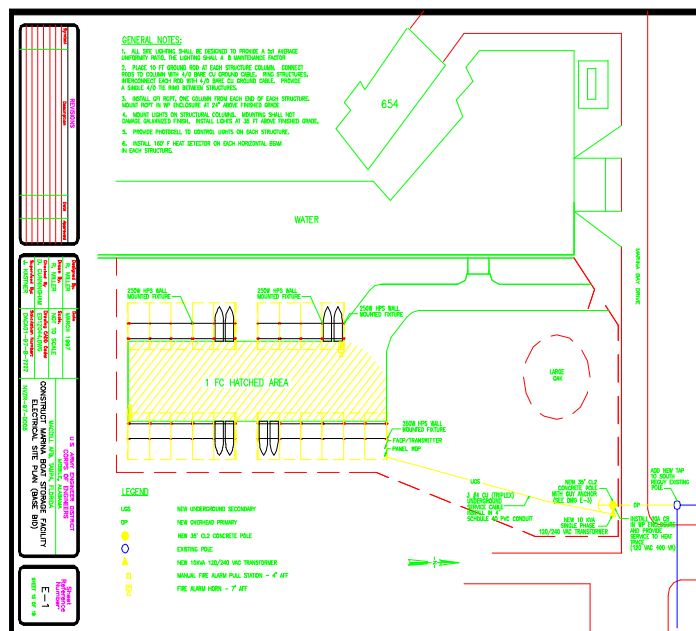
advertisement costs typically \$1500-\$1800. This is a savings of \$5200-\$5500 per project. This difference multiplied many times Corps-wide is an enormous sum of design funds that can be reduced.

In conjunction with this method of advertisement, amendments by fax, floppy disk or CD ROM also greatly reduce costs. These save time and funds since only the prospective bidders who requested the initial CD ROM and in-house personnel receive these types of amendments. No more printing hundreds of copies only to throw them away.

Internet advertisements for projects save time in reproduction and mailing costs which are also a part of the total design cost. Mobile District currently uses this method of advertisement for all projects. The site can be accessed at <http://www.sam.usace.army.mil/sam/ct>. Only prospective bidders who register at this site receive the solicitation package. This have proven to be a very successful method for advertising projects.

PAPER ADVERTISEMENTS

Some customers require this type of procurement package which is what we've all been using for years. If a project is to be advertised by this method, it should be known up front and accounted for in the total design cost. If funds become a problem later in design, the CD ROM method could be used to free up funds for design. If a project is small and is to be advertised by this method, it may be possible to use standard 215mm X 280mm (8.5" X 11") letter size paper for the drawings as well as the specifications and include the drawings in the specifications. This reduces the reproduction costs since standard drawings are much more costly to reproduced that standard letter size paper. Following is an actual drawing from a project that used this method.



**FIGURE
DRAWIN
EXAMPL**

This scope project was to construct a marina boat storage building. The drawing in figure 5 shows one

of the electrical drawings. This project has been constructed without problems using this method.

ELECTRONIC COMMUNICATIONS

The use of electronic media to communicate during design can and is a definite cost saving method. Following are examples of proven methods and further suggestions.

Video Teleconference

Travel costs (for salaries, per diem and other related expenses) can be a significant part of the overall design cost. If these can be reduced, some of the savings can be used for actual production of plans and specifications and the remainder passed along to the customer.

On a recent project, an on-board review conference was schedule to review a design submittal. Instead, a video teleconference was held. Travel for the on site meeting would have been as follows:

- Airline Tickets, 3@\$625 ea.	\$1875
- Per Diem 2 days@ \$100/day X 3 people	\$600
- Salary 3 people @ \$550/day X 2 days	<u>\$3300</u>
Total	\$5775

The cost for the teleconference was \$1500. This saved a total of \$4275. The salaries that would have been spent sitting in airports and airplanes were spent on actual production. When this method can be used in a cost effective manner, it should be used and its advantage exploited.

Electronic Mail (e-mail)

This means of communications have proven to be both a help and a hindrance. /some people e-mail one-liners back and forth until mail boxes are full. This wastes productive time. Control of this is beyond the scope of this paper. Properly utilized, e-mail can be used to a great advantage.

The Mobile District has recently undergone a reduction on forces (RIF) which eliminated one half of the Engineering Division staff. No job categories were spared. Many design disciplines were greatly reduced which has required the use of Architect-Engineer (AE) forces to fill in the gaps. The use of e-mail tor transfer drawings and other communications with the AE has been a much used tool. Coordination with the AE has been almost the same as if they were sitting in the next cubicle even though most of them are in another state. An actual cost savings cannot be attached to the use of e-mail for this task but it would probably be substantial in time saved and errors not happening. The use of AE forces to fill the gap is and will continue to be the new way to do in-house designs in these times of limited resources. The use of e-mail is a necessary tool to keep down costs.

Internet

Many manufacturers of electrical equipment have extensive sites on the internet that contain product information and complete catalogs. Obtaining this type of information has now been made much easier through the internet. Having search engines find information is much easier and quicker than thumbing through a wall full of catalogs. All employees should have access to the internet so that this means of gathering necessary technical information is a click away. Many trade magazines such as EC&M (<http://www.ecmweb.com>) and Construction Specifying Magazine have sites that contain valuable design information.

The TECHINFO site, maintained by the Huntsville Engineering and Support Center (CEHNC) contains specifications and other criteria documents and

details. It can be accessed at <http://www.usace.army.mil/techinfo/index.htm>. The Construction Criteria Base (CCB) contains all the above information plus numerous other USACE criteria documents and standards along with standards from other government agencies. It can be accessed at <http://www.nibs.org>. A subscription allows total access. Nonsubscribers can download one (1) megabyte per month. There are also instructions for obtaining the quarterly CD ROM package at no cost to DOD employees and contractors. There is no excuse to have to spend extra design funds to correct designs because criteria was not available. It is available to all of us as stated above.

DESIGN COST REDUCTION METHODS

The previous paragraphs have discussed methods for reducing design related costs which are included in the total design cost for a project. They also discussed methods to obtain current design information and criteria which can reduce costs for redesign for using old criteria. The following paragraphs discuss some procedures that can reduce the cost of the actual design documents.

SPECIFICATIONS

The Corps of Engineers has two distinct sets of specifications: CEGS (Corps of Engineers Guide Specifications) and CEAGS (Corps of Engineers Abridged Guide Specifications). The use of CEAGS, where appropriate, can reduce the costs of writing specifications.

CEAGS are suitable for small to medium sized projects. This type of specification was used for the project in Figure 5. These specifications can and do reduce the time required to write specifications since they require little editing and contain only the information required for the specific item being specified. The possibility of incorrectly editing a CEGS is vastly reduced thus minimizing errors and possible conflicts.

The Mobile District currently prepares O&M designs for an Air Force installation using the installations specifications (the installation awards and administers the construction contract). These specifications are not edited except in rare cases. They resemble the CEAGS. Since there is no editing, time is saved in the design process and is reflected in the design fee which is usually 10% or less. These specifications also list three manufacturers (or equal) for electrical equipment and devices. It is allowable, in accordance with DFARS 210.004 (b) (3) to specify brand names or equal. When this method can be used, in accordance with the regulations, time can be saved in preparation of specifications and in drawing details for inclusion in the contract drawings. It is strongly recommended that this method be used whenever it can be legally used.

PANEL SCHEDULES

One of the most time consuming tasks in the preparation of electrical design drawings is the preparation of panel schedule on the drawings. For a large project this can consume several drawings and use up a large amount of precious design time. To minimize the effect, there are some alternatives. Figure 6 below shows a panel schedule for a recently constructed project. This schedule tells the contractor exactly all he needs to purchase and install the panel. Preparation of this schedule was minimal. The use of this type of schedule (used in the private sector) was met with quite a bit of disagreement by in-house construction division personnel. It didn't look like what we'd been doing for years. After much discussion, they relented to its use. No problems resulted from its use and the customer benefitted from lower design costs.

FIGURE 6
PANEL SCHEDULES

To use something different requires a change in thinking on the part of all of the members of the design and construction team. It also save the customer money.

GUARD HOUES PANEL SCHEDULES
PANEL "GHN" 120/208 VOLTS, 1-PHASE, 3-WIRE 100/2 MAIN BREAKER ALL BREAKERS 20/1 EXCEPT CIRCUIT 10 AND 11 WHICH ARE 20/2. ALL BREAKERS 10,000 AMPS RMS SYMMETRICAL PROVIDE 4 SPARE BREAKERS
PANEL "GHS" 120/208 VOLTS, 1-PHASE, 3-WIRE 100/2 MAIN BREAKER ALL BREAKERS 20/1 EXCEPT CIRCUIT 7, A 30/2 AND CIRCUITS 8 AND 9 ARE 20/2. ALL BREAKERS 10,000 AMPS RMS SYMMETRICAL PROVIDE 4 SPARE BREAKERS
PANEL "GHN" IS LOCATED IN THE GUARD HOUSE IN FRONT OD THE SECURITY POLICE BUILDING

Another way to save funds and time is to use design software that directly exports schedules to the drawings or works interactively with the CADD software to do this task. Figure 7 shows a typical schedule of this type.

PANEL "EH"			
480/277 VOLTS, 3-PHASE, 4-WIRE			
225/3 MAIN CIRCUIT BREAKER			
ALL BREAKERS SHALL BE RATED 41,000 AMPS RMS SYM.			
CKT.	LOAD SERVED	BREAKER	FEEDER
1	PARKING LOT LIGHTS	20/1	22
2	PARKING LOT LIGHTS	20/1	22
3	TRASH COMPACTOR	20/1	21
4	TRASH COMPACTOR	20/1	21
5	LIGHTING	20/1	22
6	LIGHTING	20/1	22
7	LIGHTING	20/1	22
8	LIGHTING	20/1	22
9	LIGHTING	20/1	22
10	SPARE	20/1	
11	PANEL "EL" VIA TRANS.	100/3	13 PRIMARY 9 SECONDARY

FIGURE 7 PANEL SCHEDULE

LIGHTING FIXTURE DETAILS

The Corps of Engineers standard lighting fixture details are available from the TECHINFO web site previously addressed. Other details are available on CD ROM from the CADD Center at WES. This can be reached at <http://tsc.wes.army.mil>. These standard details, already proven and used, should be used before any attempt is made to spend design time preparing details that are already available for use. This can reduce the detailing time for a typical project by 75%.

DIGITAL PHOTOS

Digital photos, either scanned or taken with a digital camera, can be used to reduce design costs. The use of these photos can replace many hours of detailing for particular part of a design. Attachment "A" also contains an example of a photo that could be used with text annotations to replace guys, configure the pole, etc. This method can also be used successfully for small repair projects such as window and door replacements, pole upgrades, etc.

CADD

Computer Aided Drafting and Design (CADD) is probably the best tool available for reducing the overall design cost of any project. Its use can make repetitious drawing simple, allows all disciplines to share the same and current information, and can be used to overlay drawings to eliminate, or at least minimize, conflicts. If not used properly it can be our worst enemy.

In order to properly use CADD and reap its benefits, a standard system must be used and its use mandated. I know that some districts are 100% Microstation, others 100% Autocad, and still others use both platforms. There are no perfect translations between systems and problems have and do occur. Some of these problems have caused design delays even though they have appeared to have been "minor". Adopting one platform insures uniformity and makes it easier to coordinate among disciplines. The Mobile District currently uses both systems but is changing to 100% use of Microstation. This decision to change met with a lot of resistance but it should benefit the

District and the customers in the long run.

In order to properly use CADD, standard procedures for its use must be adopted and enforced. One might wonder how this can effect design costs. The Mobile District has specific procedures in place stating where the official CADD drawing files are to be stored. There have been occasions where individuals, by not following procedures, have overwritten the completed, official CADD file with an earlier, incomplete version. These files were reproduced and mailed for review which revealed the mistake. A resubmittal was required which wasted design costs (time, reproduction and mailing costs) not to mention embarrassment, which could effect future work since we're not the mandated design agency.

As previously mentioned, the CADD Center has standard details available for use. Use of these can further complement the use of CADD.

RECOMMENDATIONS

Many, if not all the cost reduction methods described herein, should be adopted for use. I'm sure that these ideas may spawn other ideas to reduce costs. Some might say that we can't make our employees do something different and change the way they've always done their jobs. Performance standards and subsequent performance appraisals can assist in enforcement of new and better ways to work.

The Corps of Engineers should adopt Corps-wide software. Sharing documents among Word, Word Perfect, Word Star, Excel, Quattro Pro, 1-2-3, etc. is a frustrating problem that wastes an inordinate amount of time. Versions change and are not always upward compatible. This would allow work done by another district to be seamlessly used by other districts with no translation problems. Living in our own little worlds is counterproductive to the Corps of Engineers as a whole.

Software to redline CADD drawings, in lieu of written design review comments (software also available in many forms and fashions), would also make it easier for districts to work together and for one another. We would all be singing from the same sheet of music.

The use of electronic design submittals, in lieu of reams of paper and shipping expenses, should be pursued. Video teleconferences, e-mail transmission of submittals (with appropriate redlining software), etc. should be pursued. The benefits of using these methods have been previously discussed.

ER 1110-345-700 requires the production of a document that is a substantial part of the total design cost. The design analysis, which consists of a narrative description of the design, engineering calculations, manufacturer's catalog cuts, job related correspondence and other project related criteria, is a document that takes possibly 10%-15% of the design cost to write, prepare, assemble, check, reproduce and disseminate. All the information contained in this document can be furnished in this document can be furnished to the customer at the end of the project, if the customer wants it. Most of the reams of calculations are never checked. Many times these volumes of materials are just discarded. This regulation should be modified to catch up with the current times (see the date of it in the REFERENCES) and incorporate into it necessary cost cutting and cost saving methods and procedures.

As this paper started, the times have changed. We must change with them if we are to remain a viable organization and survive in the fiscally tight times. To remain the same is to cease to exist.

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REFERENCES

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2. Architectural and Engineering Instructions (AEI), Simplified Design Methods (SDM) (superceded, U. S. Army Corps of Engineers, 24 January 1990
3. Design-Build Instructions, U. S. Army Corps of Engineers, 29 October 1994
4. ER 1110-345-700, "Engineering and Design, DESIGN ANALYSIS", U. S. Army Corps of Engineers, 19 February 1982
5. Engineering News Record Building Cost Analysis
6. Mobile District Historical Data, 1992

The following is a portion of a spreadsheet used by the Mobile District to calculate design costs based on design targets:

PA	TARGET	
	%	\$
<\$1,000,000	16.00%	\$160,000
\$1,000,000	16.04%	\$160,363
\$1,100,000	15.38%	\$169,223
\$1,200,000	14.81%	\$177,778
\$1,300,000	14.31%	\$186,065
\$1,400,000	13.87%	\$194,116
\$1,500,000	13.46%	\$201,955
\$1,600,000	13.10%	\$209,603
\$1,700,000	12.77%	\$217,078
\$1,800,000	12.47%	\$224,394
\$1,900,000	12.19%	\$231,565
\$2,000,000	11.93%	\$238,602
\$2,100,000	11.69%	\$245,515
\$2,200,000	11.47%	\$252,313
\$2,300,000	11.26%	\$259,003
\$2,400,000	11.07%	\$265,593
\$2,500,000	10.88%	\$272,088
\$2,600,000	10.71%	\$278,495
\$2,700,000	10.55%	\$284,818
\$2,800,000	10.40%	\$291,062
\$2,900,000	10.25%	\$297,231
\$3,000,000	10.11%	\$303,329

It was derived from the following equation:

Calculations:

If PA < \$1,000,000: Target Cost = 0.16 X PA

If PA = \$1,000,000 to \$12,000,000: Target Cost = 1,000 X [(4.433359 X SQRT(PA/1,000)) + (0.020168 X (PA/1,000))]

If PA > \$12,000,000: Target Cost = 0.06 X PA

